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CHEMISTRY.—*Unhydrated solute element ions.*[1] L. H. FLINT, Bureau of Plant Industry. (Communicated by G. N. COLLINS.)

In a consideration of the hydration of some solute element-ions as comprised in the first two papers of the present series[2] attention has been directed to a group of electrolytes whose components behaved rather consistently as hydrated ions in aqueous solution. For example, the chlorine ion, Cl^-, in solutions of the electrolytes KCl, NaCl, LiCl, $MgCl_2$, $CaCl_2$, $AlCl_3$, $CrCl_3$, $CuCl_2$, $SrCl_2$ and $CdCl_2$ as involved in measurements of electrical conductivity, seemed uniformly subject to characterization as having a hydration of seven water molecules, all the other ions also having the respective hydration values assigned them under the initial assumptions regarding hydration designated in Table 1, and interpreted through the assumption of change in weight with ionization. At this point we may examine some electrolytes which appear to give rise to unhydrated ions in aqueous solution.

Hydrochloric Acid, HCl. The relatively high velocity of the hydrogen ion, H^+, has frequently led to the conclusion that this ion is characteristically not hydrated. Various measurements of solution phenomena, moreover, have seemed to corroborate this conclusion. It will be of interest, therefore, to examine some observed relative velocities with respect to the assumptions of hydration and weight-change embodied in Table 1, and the above conclusion.

The ion-conductance of the ions K^+ and H^+ at 18°C. as cited by Creighton and Fink[3] and derived from observed electrical conductivities through the use of transference measurements, are as follows:

[1] Received March 28, 1932.

[2] This JOURNAL 22: 97–119 and 211–217, 1932. Herein are given the tables to which reference is made in this paper.

[3] Creighton, H. J. and Fink, C. J. *Electrochemistry.* Wiley and Sons, Vol. I, 1924, p. 134.

$K^+ = 64.5$, $H^+ = 313$. Referring now to Table 1 of the first paper we may derive the assigned value for the velocity of the ion K^+, considered as hydrated, in the following manner:

$K = 38$, $K^+ = 40 + 3\ H_2O\ (3 \times 18) = 40 + 54 = 94$ (weight of hydrated ion, column 7). The velocity value corresponding with this weight is 1031 (column 8).

We may now consider the above ion-conductance values as relative velocities, since each ion carries the same charge, and determine the corresponding relative velocity of the H^+ ion on the tabulated scale by solving for x in the ratio

64.5	:	313	::	1031	:	x
obs. Vel.K^+		Obs. Vel.H^+		calc. Vel.K^+		(hydrated)

$x = 5000$.

Determining the indicated relative velocity of the H^+ ion as 5000 we note that there is no such figure comprised within the series of column eight, representing velocities of hydrated ions, but that the figure corresponds precisely with the figure representing the velocity of the hydrogen ion, H^+, considered as unhydrated, given in column four and derived as follows:

$H = 2$, $H^+ = 4$ *with no hydration*, $V_1 = 5000$

The agreement is in substantiation of the above-noted conclusion.

We may now proceed to compare the observed relative specific molecular conductivity of HCl at 1.0 molecular concentration with that which would be expected under the assumption that the H^+ ion was not hydrated

$H = 2$, $H^+ = 4$, with no hydration, ionic wt.	$= 4$
$Cl = 34$, $Cl^- = 32$, with 7 H_2O, ionic wt. hyd.	$= 158$
summation wt.	$= 162$

$1000 - 162 = 838$, or 83.8% solvent.

Observed specific molecular electrical conductivities of HCl may be cited as follows:[4] 1.0 mol. = 199.85, "0" mol. = 236.92; $199.85 \div 236.92 = .844$, or 84.4%.

The order of agreement is in further substantiation of the conclusion that the H^+ ion is characteristically not hydrated in aqueous solution.

Rubidium Chloride, RbCl. The summation weight suggested by Table 1 as representing the solute present in a solution of RbCl at 1.0 molecular concentration on the weight basis if the rubidium ion, Rb^+, does not hydrate may be calculated as follows:

[4] Jones, H. C. Carn. Inst. Wash. Pub. No. 180, 1913, p. 80.

Rb = 74, Rb^+ = 76; with no hydration, ionic wt. = 76
Cl = 34, Cl^- = 32; with 7 H_2O, mol. wt. hydrated = 158
108 = mol. wt., anhyd. summation weight = 234

From this value the relative weight of solvent may be derived as 1000 − 234 = 766, or 76.6%.

The relative specific molecular electrical conductivity of RbCl at 1.0 molecular concentration may be derived from observed values at 18°C. as follows:[5] RbCl at .001 molecular concentration = 130.1; at 1.0 molecular concentration = 102; 102 ÷ 130.1 = .784, Rel. sp. mol. conductivity = 78.4%.

The apparent specific molecular conductivity at "zero" concentration may be presumed to be somewhat higher than that at .001 molecular concentration, with the relative value at 1.0 mol. somewhat lower. The agreement between the value calculated on the above basis (76.6%) and the observed value (78.4%) calculated from a somewhat low base, may be considered as evidence that the Rb^+ ion in aqueous solutions of RbCl is not hydrated.

Caesium Chloride, CsCl. The summation weight suggested by Table 1 as representing the solute present in a solution of CsCl at 1.0 molecular concentration on the weight basis if the Cs^+ ion does not hydrate may be calculated as follows:

Cs = 110, Cs^+ = 112; with no hydration, ionic wt. = 112
Cl = 34, Cl^- = 32; with 7 H_2O mol. wt. hydrated = 158
summation wt. = 270

From this value the relative weight of solvent may be derived as 1000 − 270 = 730, or 73.0% solvent.

The relative specific molecular electrical conductivity of CsCl at 1.0 molecular concentration and 18°C. may be derived from observed values as follows:[6]

CsCl, 1.0 mol. conc. = 98.8, .0005 mol. conc. = 131.05; 98.8 ÷ 131.05 = .754. Relative specific molecular conductivity = 75.4%.

The apparent specific molecular conductivity at "zero" concentration may be presumed to be somewhat higher than that observed at .0005 mol. Under the circumstances the order of agreement between the calculated value (73.0%) and the value as observed (75.4%), appears to constitute evidence that the Cs^+ ion in aqueous solutions of CsCl is not hydrated.

Although in the electrolytes HCl, RbCl and CsCl the positive ion

[5] Values cited are from Int. Crit. Tables, Vol. 6, p. 234.
[6] Previous citation.

has been indicated as unhydrated, there appears to be no reason why the absence of hydration may not characterize the negative ion. On such an assumption we may examine further as follows:

Potassium Bromide, KBr. The summation weight representing the solute present in a solution of potassium bromide, KBr, at 1.0 molecular concentration on the weight basis if the bromine ion, Br^-, does not hydrate may be calculated as follows:

K = 38, K^+ = 40, with 3 H_2O, mol. wt. hydrated	= 94
Br = 70, Br^- = 68, with no hydration, ionic weight	= 68
summation wt.	= 162

From this value the relative weight of solvent present may be derived as 1000 − 162 = 838, or 83.8% solvent.

The relative specific molecular conductivity of a 1.0 molecular solution of KBr, may be approximated from observed values at 0°C. as follows:[7] .5 molecular concentration = 65.82; .000976 molecular concentration = 79.23; 65.82 ÷ 79.23 = .831. Relative specific molecular conductivity at .5 molecular concentration = 83.1%. The corresponding value for 1.0 molecular concentration is not given in the reference cited, and would be somewhat less,—yet the indicated order of agreement appears to constitute evidence that the Br^- ion in aqueous solutions of KBr is not hydrated.

Potassium Iodide, KI. The summation weight representing the solute present in a solution of potassium iodide, KI, at 1.0 molecular concentration on the weight basis if the iodine ion, I^-, does not hydrate may be calculated as follows:

K = 38, K^+ = 40, with 3 H_2O, mol. wt. hydrated	= 94
I = 106, I^- = 104, with no hydration, ionic wt.	= 104
summation wt.	= 198

From this value the relative weight of solvent may be derived as 1000 − 198 = 802, or 80.2% solvent.

The relative specific molecular conductivity of a 1.0 molecular solution of KI may be derived from observed values at 18°C. as follows:[8] 1.0 molecular concentration = 96.8; .0005 molecular concentration = 121.2; 96.8 ÷ 121.2 = .799. Relative specific molecular conductivity = 79.9%.

The agreement between the predicted value (80.2%) and the observed value (79.9%) is of an order to constitute evidence that the I^- ion in aqueous solutions of KI is not hydrated.

[7] Jones, H. C. Carn. Inst. Wash. Pub. No. 170, 1912, p. 21.
[8] Jones, H. C. and Caldwell, B. P. Am. Chem. Journ., May 1901.

The consideration of electrical conductivity measurements of aqueous solutions of HCl, RbCl, CsCl, KBr, and KI suggests that there may be hydrated ions in association with unhydrated ions, and that the unhydrated state may characterize either the positively-charged or the negatively-charged component.

It will now be of interest to note that a similar examination of the relative specific molecular conductivities of the electrolytes cadmium bromide, $CdBr_2$, and cadmium iodide, CdI_2, leads to the conclusion that in aqueous solutions of these salts all ions are hydrated. Yet we have heretofore noted that in association with potassium as KBr and KI the ions Br^- and I^- were indicated as not hydrated. Under the circumstances it appears that the presence or absence of the hydration of the Br^- and I^- ions may be a matter of association. Since by the precepts of the present inquiry hydration conditions the velocity of an ion it follows that we have come into variance with the Kohlrausch Law of the Independent Migration of Solute Ions, which holds velocity as independent of association.

In connection with the consideration of the hydration characteristics of inorganic and organic molecular ions in subsequent papers of this series it will be of interest to note from time to time further evidence that association may condition the presence or absence of hydration. Within the limits of a specified state, hydrated or unhydrated, the Law of Kohlrausch has been shown in this and in the foregoing papers to be applicable in substantial measure to concentrated solutions. Yet with the accession of additional evidence that the two states, hydrated and unhydrated, may characterize the ions of the same elements in different electrolytes, it would appear that the law would fail as a correct description of velocity relationships.

CHEMISTRY.—*Lignin-like complexes in fungi.*[1] CHARLES THOM and MAX PHILLIPS, Bureau of Chemistry and Soils.

Recent papers dealing with the decomposition of plant residues (Waksman and associates)[2] point to the lignins as decomposing more slowly than other plant constituents, hence as tending to accumulate as a result of the rotting of plant materials. The abundance of these lignin-like complexes in soil organic matter is noted as confirmatory evidence. The accumulation of the remains of soil microörganisms is also indicated as one source of these slowly decomposing substances.

[1] Received April 1, 1932.

[2] Summarized with bibliographic notes by Waksman, S. A. *Principles of Soil Microbiology.* Ed. 2. Chapter 24. 1932.

Additional information as to lignin-supplying organisms becomes therefore of interest.

Every field student of the fungi is familiar with the abundance of black and brown (dematiaceous) species upon the surfaces of decaying vegetation. They give a dirty black brown color to plant remains in the field and the fence corner during the moist portions of the year. Many of them are less familiar with the fact that these organisms predominate only in the presence of air and light. They are not commonly found actively vegetating entirely below the surface of the soil. In connection with our studies of decaying crop residues, certain analyses have been made in the Bureau of Chemistry and Soils, which may be worthy of record.

Four of these species common on the soil and on decomposing plant remains, were grown upon Czapek's solution which presents sucrose as the only source of carbon. These were incubated until thick masses of dark mycelium were developed. The cultures were then filtered through sintered glass Jena crucibles, washed with water, dried at 105°C. The dry material was extracted with a 1:1 alcohol-benzene solution, dried and analyzed for lignin by the fuming hydrochloric acid method (J. Assoc. Off. Agric. Chemists **15**; 124. 1932). The percentage of lignin was calculated on the oven-dry (105°C.) material.

The results of the analyses have been tabulated as follows:

Species	Per cent Lignin
(1) *Alternaria* sp	17.25
(2) *Epicoccum* sp	20.30
(3) *Sclerotinia libertiana* (with sclerotia present)	7.85
(4) *Cladosporium* sp	29.27

The amount of lignin found was sufficiently striking to suggest the analysis of certain bracket fungi.

Species	Per cent Lignin
Hydnum caput-ursi (pure white)	2.65
Polyporus sulphureus (sulphur yellow)	3.40
Trametes pini (deep brown)	54.08
Fomes igniarius (almost black)	36.95

There is a marked contrast between the pure white *Hydnum* and the sulphur yellow *Polyporus* on the one side and the deep brown *Trametes* and almost black *Fomes*, on the other. Confirmatory analyses of other cultures and samples support the view that the dark brown, leathery, black and carbonaceous masses produced by whole groups of fungi are high in organic complexes of a lignin-like character, whereas the colorless or light colored fungi have little lignin-supplying power.

A possible relationship to soil organic matter might be suggested by the predominance of black and brown molds on vegetation decaying at and just above the surface of the soil as such decomposition occurs under natural or so-called "virgin" soil conditions. Brown and black forms produce very little growth in material plowed under, hence play little part where clean cultivation involves covering all crop residues with several inches of earth.

CONCLUSION

In the analyses reported (a), the brown walled molds such as *Cladosporium* and *Alternaria* contain high percentages of lignin-like substances (such as 17.25 to 29.27% in dry matter) upon culture media presenting sucrose as a sole source of carbon. (b) Brown walled bracket fungi such as *Trametes pini* and *Fomes igniarius* contain even higher percentages of these "lignins." (c) The light colored bracket fungi showed correspondingly little lignin-like substance.

PALEONTOLOGY.—*New species of fossil Raninidae from Oregon.*[1]

MARY J. RATHBUN, U. S. National Museum.

From time to time Dr. Hubert G. Schenck of Stanford University has given to the National Museum various crustaceans from the Tertiary of Oregon. Among them are four new Raninidae which are here described and will be incorporated in Schenck's report on the region.

Raninoides oregonensis, new species

Seemingly related to *R. eugenensis* Rathbun[2] from the Oligocene of Lane County. Anterior portion of carapace lacking. Carapace broadest at anterior ⅔, broader than in *eugenensis*, but like that species, convex from side to side and sloping gradually downward on the median line from the anterior to the posterior end. Surface covered with minute granules not visible to the naked eye and with the tips rubbed off, appearing like punctae. A lateral spine near anterior fifth and directed obliquely forward is broken off near base. Length (estimated) 38, greatest width behind spines 32, posterior width 16 mm.

Type-locality.—Near Dallas, Polk County, Oregon; limestone formation, Eocene. Cat. No. 371922, U. S. N. M.

Lyreidus alseanus, new species

The specimen, encased in a nodule, was originally longer and flatter than at present. The carapace is cracked across the widest part and again across

[1] Published with the permission of the Secretary of the Smithsonian Institution. Received February 25, 1932.

[2] Bull. 138, U. S. Nat. Mus., 1926, p. 96, pl. 24, fig. 4.

the front half, the broken edges overlapping each other and at the middle pushed upward. There is also a longitudinal break at the left of the median line. Front narrow, widening a little at extremity; at the left 2 rounded lobes separated by a subrectangular sinus and succeeded by a rounded sinus,

Fig. 1. (Left) *Raninoides oregonensis*. Dorsal view of carapace of holotype, showing lateral spine, x 1-1/2.

Fig. 2. (Right) *Raninoides oregonensis*. Same specimen from the right side, showing part of lower surface, x 1-1/2.

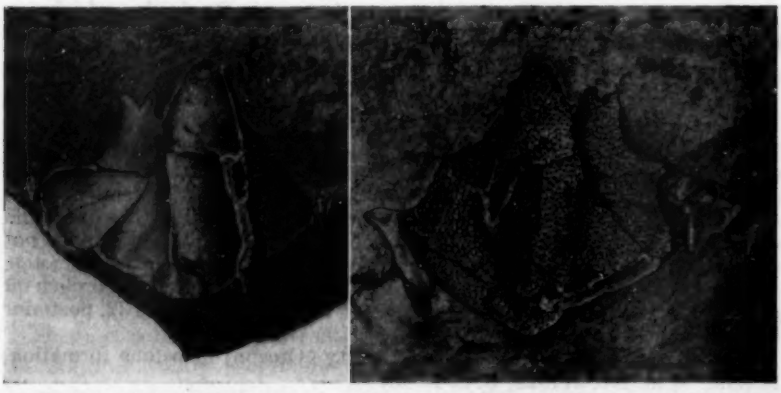


Fig. 3. (Left) *Lyreidus alseanus*. Dorsal view of an inner layer of carapace of holotype, cracked and out of shape, x nearly 2.

Fig. 4. (Right) *Lyreidus alseanus*. Lower side of upper layer of carapace of same specimen, x nearly 2.

all of which occupy half or nearly half the front. Carapace widening rapidly from rostrum to lateral angle, in front of which on the right side there is a small knoblike tooth, longer than broad, curving forward and away from the antero-lateral margin; just outside this tooth is the impression of another.

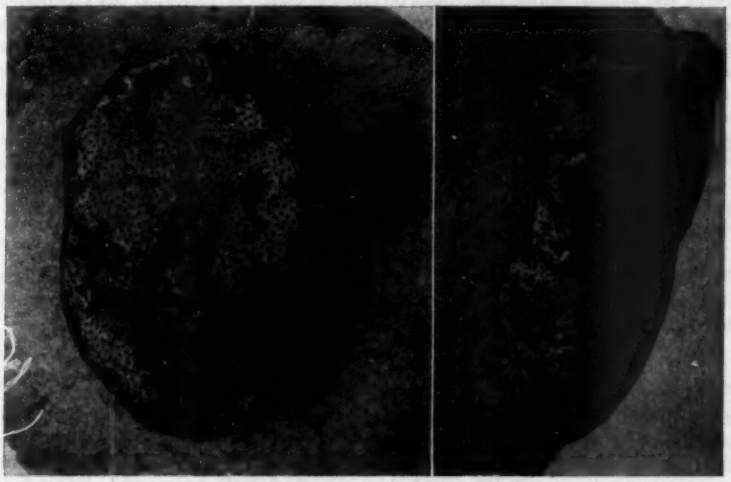


Fig. 5. (Left) *Eumorphocorystes schencki*. Dorsal view of carapace of holotype showing antero-lateral spine, x 1-1/2.

Fig. 6. (Right) *Eumorphocorystes schencki*. Left profile of same carapace, x 1-1/2.

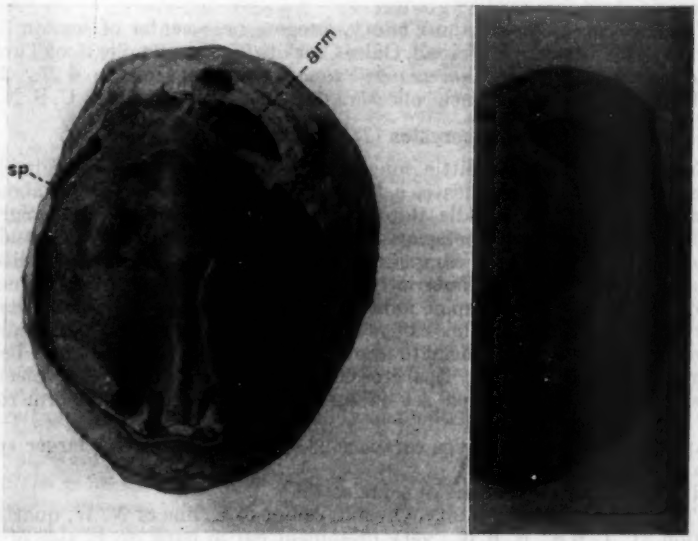


Fig. 7. (Left) *Eumorphocorystes leucosiae*. Dorsal view of carapace of holotype showing origin of lateral spine and portion of right arm, x 2.

Fig. 8. (Right) *Eumorphocorystes leucosiae*. Left side of holotype showing chela and fragments of legs, x 2.

Behind the lateral spine the angle of the carapace is rounded and the postlateral margins are blunt and converge rapidly toward the posterior end. Exposed dorsal surface with some fine granulation near antero-lateral border; this is, however, not the true outer layer which is shown in the opposing half of the nodule (Fig. 4); its under surface is exposed and is covered with large, smooth, almost contiguous granules, which in the reverse or upper layer must appear as so many pits. At the lateral angle on what is the true right side there is a tooth pointing directly outward; this is a stout, blunt tooth similar to the one described above but straighter; one or two of the teeth or spines indicated may belong to the carpus of the cheliped.

Apparent length of carapace 24.6, width 23.7 mm.

Type-locality.—Tuffaceous sandstone on S. side of Alsea Bay about $\frac{1}{8}$ mile E. of B.M. 12, and $\frac{1}{4}$ mile E. of Waldport, Lincoln Co., Oregon; Sec. 20, T. 13 S., R. 11 W. Lower Oligocene. Sept. 14, 1926. Hubert G. Schenck. Cat. No. 371901, U. S. N. M.

Eumorphocorystes schencki, new species

Two carapaces, very convex from front to back, more so from side to side. Shape, broad oval, width 40 mm., length about 45. Front narrow, about $\frac{1}{3}$ as wide as carapace excluding spines; details obscure. A spine at anterior third of lateral margin or about 15 mm. behind margin of front; spine 6.7 mm. long, tapering to a slender point and directed well outward. Behind the spines the side margins are parallel along the middle third. Posterior margin somewhat wider than anterior, and slightly convex. Surface covered with large round pits, irregularly disposed, rarely in contact. A blunt, longitudinal, median carina the length of the carapace, becoming widest between the crescentic, branchio-cardiac grooves.

Type-locality.—Washington County, Oregon, near center of section 3, T. 2 N., R. 5 W., Beaver Creek road, Gales Creek to Timber, 3 miles S. of Timber. Keasey formation, "*Cardium weaveri*" zone, Oligocene, Holman # 27. John T. Holman and H. G. Schenck collectors, 1931. Cat. No. 371921, U. S. N. M.

Eumorphocorystes (?) leucosiae, new species

Carapace subglobular, little longer than broad, posterior margin $\frac{1}{2}$ as wide as carapace, subtruncate, a little concave at middle; front about $\frac{1}{3}$ as wide as carapace; middle third of lateral margins subparallel. Surface covered with small pits, interspaces rough with fine granules; two longitudinal furrows through middle of carapace, near together at posterior third, diverging at either end, more so anteriorly; intermediate surface convex; branchial regions swollen. Lateral spine indicated at anterior third of lateral margin. Left chela uncovered, palm elongate, widening distally, half as wide as superior length, bluntly carinate above and armed with four spines below. Fingers strongly deflexed, tips crossing, prehensile edges wavy, meeting, outer edges carinate, carinae set off by a furrow. Fragment of arm rough like carapace.

Approximate length of type carapace 28.6, width 23 mm. A larger specimen is 30.3 x 26.2 mm.

Has much the appearance of a Leucosiid.

Type-locality.—Polk County, Oregon, center of E. line of N. W. quarter of Section 21, T. 6 S., R. 6 W.; very prominent cut in bank on E. side of Mill Creek, visible from road from Buell to Sheridan. Formation probably Keasey, "*Cardium weaveri*" zone, Oligocene. Holman # 1. John T. Holman collector, 1931. Cat. No. 371902, U. S. N. M.

ZOOLOGY.—*Nematosis of a grass of the genus* Cyanodon *caused by a new nema of the genus* Tylenchus *Bast.*[1]

N. A. COBB, Bureau of Plant Industry.

Tylenchus[2] *tumefaciens* n. sp. $\frac{0.6}{1.2}$ ..... $\frac{3.6}{2.6}$ ..... $\frac{?}{?}$ ..... $\frac{88.4}{4.3}$ ..... $\frac{96.8}{1.9}$ 1.4 mm.

The posterior swelling of the oesophagus in this species seems to be somewhat set off from the intestine. The *reflexed portion of the ovary* contains the ova in about three ranges or rows, and appears one-third as wide as the corresponding portion of the body, and *has a length about twice as great as that of the neck.* At the blind end of the ovary there is a special single cell, taking up the full width, and having a distinct, clear, spherical nucleus, nearly one-third as wide as the cell. The nucleus contains a fairly granular spherical nucleolus half as wide as the nucleus itself. The immediately adjacent ova differ in having larger granular nuclei with somewhat larger but similar nucleoli. In this reflexed portion of the ovary the ova as they pass cephalad increase slightly in size, but do not exhibit much detail in structure. Passing around the flexure, the ova slowly begin to change in structure, and by the time they are opposite the blind end of the ovary, the nuclei begin to show chromosomes.

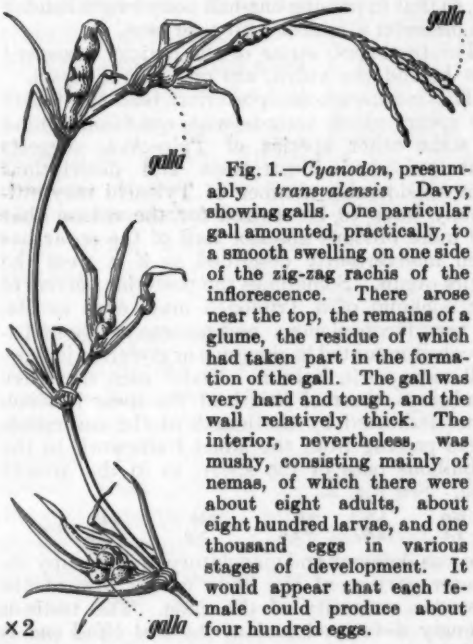


Fig. 1.—*Cyanodon*, presumably *transvalensis* Davy, showing galls. One particular gall amounted, practically, to a smooth swelling on one side of the zig-zag rachis of the inflorescence. There arose near the top, the remains of a glume, the residue of which had taken part in the formation of the gall. The gall was very hard and tough, and the wall relatively thick. The interior, nevertheless, was mushy, consisting mainly of nemas, of which there were about eight adults, about eight hundred larvae, and one thousand eggs in various stages of development. It would appear that each female could produce about four hundred eggs.

The large transverse *vulva spans the ventral fourth*, or even the third of the body, and is so massive that sometimes the *part of the body behind is bent dorsad at an obtuse angle.* The acute tail is nearly straight, slightly convex-conoid; it may be even slightly dorsally arcuate. *Anus inconspicuous. The massive uterus*, occupying most of the corresponding body cavity, *usually contains but one egg.* The spherical spermatozoa, packed in the uterus so as to be more or less polyhedral, are about one-fourth as wide as the body of the female; they are finally granular

[1] Received April 1, 1932.

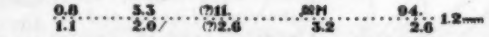
[2] The genus name *Tylenchus* is used here instead of a recently discovered prior synonym because of the author's confidence that if and when the attention of the International Commission on Zoological Nomenclature is called to the matter it will decide that far greater confusion and inconvenience will be caused by following the rule of priority in this case than in not following it, and will abrogate the rule, as it has power to do in such cases.

and contain a nucleus half as wide as themselves, which is more granular, and which contains a distinct, highly refractive, spherical, structureless-looking nucleolus about one-third to one-fourth as wide as the nucleus itself. Notwithstanding the size of the sperms, a fertilized female may contain hundreds of them. The matured ova are rather coarsely granular, are pressed one against another in the ovary and sometimes appear wider than they are long, and in some parts apparently are packed more densely than double file. *At the vulva the body of the female suddenly diminishes* in diameter, so that in passing one-half body length caudad the diameter diminishes fifty per cent.

Fig. 2.—A gall from the tissues of the base of a leaf sheath. A portion of the sheath tissue pulled away nearly intact. The inner tissues of the sheath had produced the wall of the tumor. The mushy interior was very distinct from the wall, and occupied a distinct cavity, in which the nemas lay loose, free to move about. The nine adult nemas and the numerous eggs and larvae shown were taken from another gall of *the same size*. Thus the picture shows a gall and a corresponding nemic population.

The transverse striae of the cuticle, measured just behind the vulva, are one micron apart.

The inconspicuous, posterior, bulbous half of the spear, which accords with conditions found in some other species of *Tylenchus*, suggests that published illustrations and descriptions of a considerable number of Tylenchi may ultimately have to be revised for the reason that the more obvious anterior half of the spear has been inadvertently described as if it were the entire organ. Sometimes the posterior portion of the onchium of a Triplonch may, even in life, be very inconspicuous and become nearly invisible when mounted in glycerine or glycerine jelly,—still more so in balsam. Under such deceptive conditions the real length of the spear is sometimes indicated by the length of the contractile fibers passing from the labial framework to the tribulbous base of the spear, as in the present case. See Fig. 3.



The vas deferens and ejaculatory duct occupy the greater portion of the body cavity toward the posterior extremity of the male. The testis is strongly developed and at its *bent blind end* is slightly expanded, measuring there about one-half the corresponding body diameter. At first the primary spermatocytes contain large subspherical nuclei with distinct nucleoli, the nuclei being one-fifth to one-sixth as wide as the corresponding portion of the body.

Habitat: Found in small galls on the above-ground parts of the grass *Cyanodon sp.*?,—presumably *C. transvalensis*. (*Fide* A. S. Hitchcock). The plants are killed by the parasite, the grass dying off in patches. Sent by Dr. Potgetier, from Pretoria, South Africa.

Diagnosis. **Tylenchus tumefaciens** n. sp. *Tylenchus* Bastian, formed and dimensioned as indicated in the formulae, illustrations and italicized text.

This nematosis[3] has recently come to notice in a number of Bradley grass lawns in Johannesburg and Pretoria. It seems probable that it occurs widely. Usually it is first noticed in small patches. A close examination of a diseased plant discloses greenish or reddish lumps up to the size of a canary seed, occurring on the stems and leaves,—less often in the inflorescence. Breaking these tiny galls, one discovers with a magnifying glass that the interior of the gall is inhabited by nemas, the cause of the disease. An infestation of one Pretoria lawn was traced to another lawn, from which some planting grass had been taken.

The tiny galls, or tumors, on the grass are so inconspicuous that they might easily escape notice and the disease be unwittingly spread. Once present, the disease accumulates, and after a year or more, patches of ailing grass become apparent. The pest is believed to have been present in Pretoria for some years. The abandonment of one variety of lawn grass[4] is probably due to this disease.

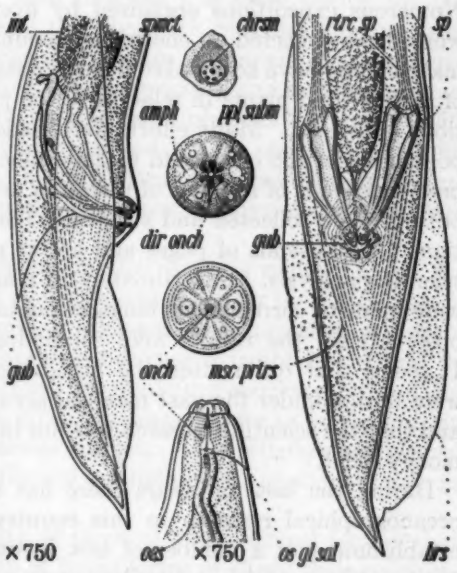


Fig. 3.—Lateral and ventral views of the tail end of the same male specimen of *Tylenchus tumefaciens* n. sp. Below, head of the same, dorsal view. The upper small figure is of a spermatocyte whose nucleus shows chromosomes. Of the two middle figures, the upper is a front view of the head, showing the four submedian papillae and the two duplex amphids, while immediately below is an optical section at the base of the lip region, each magnified about fifteen hundred diameters.

Precautions. 1. Prompt burning off of diseased patches after spraying with inflammable liquid,—i.e. kill the tops, not the roots. 2. Avoidance of seed and cuttings from infested areas. 3. Unusually careful inspection of grass cuttings used as sets. 4. Recleaning of suspected grass seed.

[3] Abstract from *South African Gardening and Country Life* **15**, Jan., 1925.
[4] Variety "Red Quick Grass," presumably a species of *Cyanodon*. N. A. C.

ZOOLOGY.—*The life in the ocean from a biochemical point of view.*[1]

PAUL S. GALTSOFF, United States Bureau of Fisheries.

For many years the interest of zoologists engaged in a study of marine life centered around morphological and taxonomic problems. Numerous expeditions organized by every civilized country of the world have collected an enormous amount of zoological and botanical material and have accumulated many data concerning the distribution of animals and plants in relation to the physical and chemical conditions in the sea. Many efforts were made to take a census of the total population of the ocean and to determine its fertility. For that purpose thousands of samples of plankton and of the forms living on the bottom were collected and studied. The reports of these investigations fill thousands of pages and are at present available for further scientific analysis. Unfortunately in many instances when attempts were made to correlate the biological data with physical and chemical observations, the results were conflicting and difficult to interpret. It seems that quite often the broader problems of oceanic biology were buried under the vast material accumulated by the expeditions, and that the scientific research was not in proportion to the effort and money spent.

During the last ten years there has been a revival of interest in oceanographical research in this country, which culminated in the establishment of a number of new institutions for the study of the ocean. The question naturally arises as to what are the outstanding problems in modern oceanography which justify both the expenditure of large sums of money and of human effort. It is quite obvious that the continuation of purely taxonomic and descriptive investigations so extensively carried out since the time of the *Challenger's* expedition will not help in unravelling the complicated relations that exist between the inhabitants of the sea and their environment; neither will they determine the factors that control their propagation and distribution in the ocean.

One of the main results of previous studies was a recognition of the fact that the population of the sea is subject to regular cyclic changes. Certain forms appear during definite seasons, reach the maximum of their abundance, then decline and give place to another group of forms, which pass through a similar cycle. Inasmuch as these changes are

[1] Received February 9, 1932. Third paper in a symposium, *Major problems of modern oceanographic research*, at the meeting of the American Association for the Advancement of Science, at Pasadena, Calif., June 17, 1931.

very pronounced in planktonic forms, like diatoms or dinoflagellates, most of the investigations concerning the periodicity of life cycles refer to these organisms. However, cyclic changes occur also in nektonic and benthonic forms. Many speculative theories were advanced to explain this phenomenon. Real progress was made during the last decade by the investigators of the Plymouth Station (England) who have demonstrated that cyclic changes are accompanied by profound changes in the chemical composition of sea water, and that the decrease or increase in the amount of various salts (phosphates, nitrates, silicates) can be correlated with the abundance or scarcity of various planktonic forms. Thus the morphological and taxonomic investigations in oceanography gradually give place to physiological and biochemical research.

The propagation of organisms in the ocean is dependent on the presence of various elements which are necessary for the building up of their bodies. Lack of a necessary element or its presence in a state not available for a given organism becomes a factor preventing its growth and propagation. Thus, the minimum concentration of any substance indispensable for a given organism becomes a factor limiting the propagation of this particular species. This principle established by Liebig and known as the "law of a minimum" is applicable both to land and marine forms.

There exists a great variety of physical and chemical factors that may interfere with the growth of living forms or check their propagation. On the other hand a temporary absence of limiting factors may result in an extremely rapid propagation of the organism which, in a short time, may fill up all the space available for its growth. Such a phenomenon, quite common in unicellular and planktonic forms, has been very appropriately called by Vernadsky "an explosion of life." It is often observed in fresh water ponds or in enclosed bays. The best example of it in the sea is found in a sudden propagation of a diatom *Aulacodiscus kettoni* along the Copalis beach in the state of Washington, where under certain conditions described by Becking and others[2] it develops in a nearly pure culture. As a result of this rapid development a large amount of phosphates, nitrates, silicates, and other salts, are withdrawn from the sea water, accumulated in the bodies of the diatoms and deposited in a thick layer on the bottom. The process continues for several days, then ceases, to recur again after a

[2] Becking, L. B., Tolman, C. F., McMillin, H. C., Field, J., and Hashimoto, Tadaichi. Economic Geology **22**: 356–368. 1927.

period of inactivity which may last for several weeks. The development of *Aulacodiscus* is a good example of a dynamic equilibrium that exists between the living organism and the surrounding medium. The diatom withdraws from the solution and accumulates in its body several elements that were present in the water, producing considerable change in the chemical composition of the latter which, in turn, becomes a factor limiting its further growth and propagation. There is no doubt that every organism behaves in a similar way differing only in the velocity and type of chemical reactions involved in its activity.

The biochemical rôle of organisms in the ocean can be understood by comparing the chemical composition of sea water with that of the

TABLE I.—THE AVERAGE COMPOSITION OF SEA WATER (ACCORDING TO W. I. VERNADSKY)

Elements	Per cent	Elements	Per cent
O	85.80	Fe	1.5×10^{-4}
H	10.67	Ag	1×10^{-4}
Cl	2.07	P	$n \times 10^{-4}$ ($n \times 10^{-5}$)
Na	1.14	Ar	5×10^{-5}
Mg	1.4×10^{-1}	I	$n \times 10^{-5}$ (n 3)
S	9×10^{-2}	F	3×10^{-5}
Ca	5×10^{-2}	B	$n \times 10^{-5}$
K	4×10^{-2}	Cu	$n \times 10^{-5}$ (n = 1 or 2)
C	3.5×10^{-3}	Li	6×10^{-6} (8×10^{-6})
Br	2×10^{-3}	Au	1.2×10^{-6}
N	1.6×10^{-3}	As	1×10^{-6}
Rb	1.5×10^{-3}	Th	1×10^{-6}
Si	$n \times 10^{-4}$ (n = 3?)	Zn	$n \times 10^{-7}$ (n 1.2?)
		Ra	$n\ 1.4 \times 10^{-12}$

living matter. In this attempt we meet with an unexpected difficulty. Our knowledge of the chemical composition of sea water is very inadequate. Most of the analyses deal with the salts that are found in relatively large concentrations, and neglect the elements occurring in very small amounts. Yet, as it will be shown later, the physiological rôle of the latter may be of great importance, and their presence in the water may be prerequisite for the propagation and development of certain forms. The most complete summary of the present state of our knowledge of the chemical composition of the sea water is given by Vernadsky[3] in Table I.

[3] Vernadsky, W. Rev. Gen. d. Sc. Pures et Appliques, **35**: 5–13. 1924. *La Geochimie.* 1924. Libr. F. Alcan. Paris.

An examination of Table I shows that our knowledge of the composition of the sea water is far from being complete, and that for a number of elements the quantitative data are only approximate. The table does not contain data for Al, Pb, Ti, Sr, and V which were found in certain marine organisms and probably occur also in sea water. On the other hand, one must bear in mind that the investigations of Atkins, Nathanson, Harvey and others have demonstrated that the concentrations of nitrates, phosphates, and silicates, do not remain constant, but are subject to considerable fluctuations, depending on the activity of the organisms. Thus, the old conception of the constancy of the chemical composition of sea water, established by Forchhammer in 1850–1860, and up to present time generally accepted in oceanographical literature, should be considered with certain reservations. We know that not only does the salinity (i.e. the total amount of salts in solution) vary in different localities, but that there exist considerable fluctuations in the proportion of certain salts. Although the absolute figures may appear insignificant (for instance the phosphate content of the water in the Faeroe-Shetland Channel varies from a few to forty milligrams per cubic meter), they may have a strong effect on the population of the sea.

A comparison between the chemical constituents of the sea water and those of the living matter convinces us that many of the elements that occur in the sea in a highly dispersed state are accumulated in the bodies of the living forms. Unfortunately, whereas the chemical composition of the sea water is not well known, our knowledge of the chemical composition of the living matter is even more fragmentary. According to Vinogradov[4] less than one-half of one percent of all the living species have been subjected to elementary chemical analysis, which in most of the cases dealt with only a few elements. Analyses of the whole body of the organisms are also nearly absent, the chemical data usually referring to the composition of the separate organs, skeleton, or blood.

Excepting the well known work of Bütschli[5] and a general review of Aron[6] the information regarding the chemical composition of various organisms is available mainly from the mineralogical literature and refers almost exclusively to the skeletons and shells. The most impor-

[4] Vinogradov, A. "Priroda" No. 3, pp. 230–254. 1931.

[5] Bütschli, O. Zool. Anz. **30**: 784. 1906. K. Gesell. Wiss. Göttingen, Math-Physik. Kl. **6**, Band 6. 1908.

[6] Aron, H. Oppenheimer Handbuck d. Biochemie, I, p. 62. 1909.

tant contributions are those of Cayeux,[7] Samoilov,[8] Vernadsky and Clarke and Wheeler.[9] These investigations closely connect the problems of marine biology with geology and mineralogy, and stress the rôle of living forms in the origin of various minerals of sedimentary rocks.

A survey of available literature on the subject reveals that the same elements that are found in the sea water occur also in the organisms, although in entirely different concentrations. Some of them as for instance calcium, sulphur, potassium, carbon, nitrogen, silicon, iron, phosphorus, iodine, fluorine, boron, copper, zinc, manganese, vanadium, lead, and titanium are concentrated in the living matter while others, as for example sodium, chlorine, bromine, magnesium, occur in it in concentrations approximately equal to that in the sea water.

TABLE II.—ACCUMULATION OF ELEMENTS BY LIVING MATTER

Elements	Concentration Times
S	100
P	1000
Si	1000
K	10
Fe	100
Zn	10,000
Cu	100
I	100
As	100
B	10
F	10

Vernadsky gives estimates (Table 2) of the minimum concentration of various elements in the bodies of marine forms, as compared with their concentration in the sea water. The figures do not refer to any particular organism but are the averages for the living matter in general.

Although it is known that Al, Mn, Pb, Ti, and V are accumulated by the organisms, it is impossible at present to express their concentrations in definite figures.

Marine plants and animals can be grouped on the basis of the ele-

[7] Cayeux, L. *Introduction à l'étude pétriographique des roches sédimentaires.* Paris. 1916.

[8] Samoilov, J. Mineral. Magazine **18**: 87. 1917. Comp. Rend. d. XIII, Congr. Geolog. Intern. 1924. Centr., of Mineral. 19, 594. 1924.

[9] Clarke, F. W., and Wheeler, W. G. Proc. Nat. Acad. Sc. 1, p. 262. 1915. U. S. Geol. Surv. Prof. Paper 124. 1922.

ments that are accumulated by their bodies. The space of this paper does not permit us to give a complete list of them, and we have to restrict our discussion to a few outstanding examples. We begin with the accumulation of calcium. According to Clarke[10] the annual deposition of calcium in the sea amounts to 1400 million tons. The greatest rôle in the process of withdrawing lime from solution and depositing it on the bottom should be attributed not to the vertebrates, corals, molluscs or other larger organisms with calcareous skeleton, but to the smallest Protozoa belonging to the group of Coccolithophoridae. Their importance in the deposition of calcium was suggested by Lohman,[11] who found that every twenty-four hours one-third of the population of these forms dies and sinks to the bottom, where it takes part in the formation of calcareous deposits.

The skeletons of marine organisms accumulating calcium are built either of calcium carbonate (aragonite and calcite $CaCO_3$; dolomite, $CaCO_3MgCO_3$) or calcium phosphate ($3Ca_3(PO_4)_2CaCO$) and apatite $(CaF)Ca_4P_3O_{12}$. A study of the chemical composition of shells of Brachiopods and Echinoderms by Clarke and Wheeler (1915, 1922) reveals an interesting fact that there exists considerable difference in the composition of the skeleton of various forms belonging to the same class. According to their work, the Brachiopods fall into two distinct groups; the shells of one consisting mainly of calcium carbonate with little organic matter, while the shells of the other group are formed mainly of calcium phosphate with much organic matter. The first group is represented by species of *Terebratula*, *Crania*, *Waldheimia*, and others, while the second group comprises *Lingula*, *Discinisca*, and *Glottidia*. The two groups are physiologically quite dissimilar, the chemical reactions involved in building the shells being of two different orders. Such a distinction, said Clarke, "ought to be significant to biologists and it is for them to determine what it means." Unfortunately, the biologists know very little about the reactions involved in building of shells and the significance of the difference just described is not understood.

Evidence that difference in the chemical composition of animals can be correlated with their habitat, and possibly with the temperature of the water in which they live, is found in another paper of Clarke and Kamm[12] dealing with the analyses of Echinoderm shells. Different species of starfishes show, according to this paper, a progressive enrich-

[10] Clarke, F. W. *Data of Geochemistry*. 1924. Washington.
[11] Lohmann, H. Intern. Rev. Ges. Hydrol. 1: 309–323. 1908.
[12] Clarke, F. W., and Kamm, R. M. Proc. Nat. Acad. Sci. 3: 401. 1917.

ment in magnesia following an increase in the temperature of their habitat. In the specimens from high latitudes or from deep water the proportion of magnesium carbonate ranges from 7 to 10 percent, while those from tropical waters contain from 11 to over 14 percent. We have at present no explanation to offer for the existence of such differences. These examples show very plainly that even within one taxonomic group the organisms differ from each other not only morphologically but also in the chemical composition of their bodies.

The cycle of silicon and the accumulation of this element by diatoms, radiolaria, and siliceous sponges is another oceanographical problem which attracted a great deal of attention. The rôle of the diatoms in the life of the ocean is well known to everybody acquainted with oceanographical problems. However, the question concerning the source of silicon, which is used by diatoms for building their tests remains unsolved. Murray has expressed a view that the amount of silicon found in solution in the sea water is insufficient to supply the demands of the diatoms and that the latter obtain this element by splitting the clay particles suspended in water. Later on (Murray and Irvine[13]), he was able to show experimentally that *Navicula* can live in water containing no silicon in solution, but only in suspension. These findings were corroborated by Vernadsky[14] who observed the formation of aluminum hydrates in the culture of *Nitzchia* grown together with the unidentified bacteria in a medium which contained silicon only in a form of suspended clay particles. It is known that the minerals, like mica, epidote, nephelene and others, transform into kaolin without changing their kaolin nucleus which has the following composition— $H_2Al_2Si_2O_8H_2O$. The kaolin nucleus is a very stable chemical compound which withstands heating up to 1000°C., but can be split by treatment with concentrated H_2SO_4 at 100°C. Yet it is apparently decomposed by the action of the organisms. The question is still open whether this is due to the activity of the diatoms or should be attributed to the bacteria that were grown in the diatom cultures.

We may briefly mention other organisms which are accumulators of various elements. It is a well known fact that iodine, which occurs in the sea in minute amounts, is accumulated by algae, gorgonacea, and sponges. In the latter it is found in the form of an albuminoid ($C_{66}H_{87}I\ N_{10}S_2O_2$). The amount of iodine in these organisms varies

[13] Murray, J., and Irvine, R. Proc. R. Soc. Edinb. **18**: 245. 1891.

[14] Vernadsky, W. Comptes. Rend. Acad. Sci., Paris, 450–452. 1922. Rev. Gen. d. Sc. Pures et Appliques, **34**: 42. 1923.

from 1.7 percent of dry substance (*Gorgonia acerosa*) to 7.8 in *Gorgonia clavellina*. Small amounts of iodine were observed in various molluscs and fishes. The physiological significance of this element in the metabolism of these forms is unknown.

The presence of copper in the bodies of marine invertebrates has been an object of numerous investigations. It is well known that copper enters into the composition of a respiratory pigment, haemocyanin, which in several forms (lobster, shrimps, crawfish and others) plays the rôle of haemoglobin. Copper was found also in a Coelenterate, *Anthea cereus* (2.35 mg. per 100 gr. wet weight); in Echinoderms, *Stichopus regalis*, (2.83 mg.), *Asterias rubens*, (2.45 mg.); in various molluscs, and in sardines, herring and salmon.

In the lamellibranchs that can accumulate copper in considerable amounts the metal occurs not as a protein compound but in a simpler form. It has been known for many years that in certain sections of the Atlantic coast, and around the British Isles, the oysters become green. The green pigment was associated with an increase in their copper content. It was thought that the pigment might be haemocyanin or at least similar to haemocyanin in chemical composition. Recent investigations by Galtsoff and Whipple[15] have shown that the green pigment of oysters is not haemocyanin or copper proteinate of any kind. It passes through a collodion membrane which holds back congo red and is not precipitated by sodium sulphate. Although its chemical nature remains undetermined, it has been found that the pigment exists in a highly dissociated state and is of a small molecular size.

The amount of copper accumulated by oysters is very variable. According to the determinations of Galtsoff and Whipple the copper content in normal oysters from Cape Cod varies from 0.16 to 0.24 mg. per oyster or from 8.21 to 13.77 mg. per 100 grams of dry weight. The amount of copper concentrated in green oysters from Long Island Sound varied from 1.24 to 5.12 mg. per oyster or from 121.71 to 271.91 mg. per 100 grams of dry weight. On the average there was about 2.5 mg. of pure copper in every green oyster. Knowing the copper content of green oysters and the extent of oyster beds affected by greening, it is possible to estimate the amount of copper which oysters withdraw annually from the water. There are at least 10,000 acres of oyster bottoms in Long Island Sound which produce green oysters. Assuming that oysters become green in one year, and that there are one

[15] Galtsoff, P. S., and Whipple, D. V. Bull. Bur. Fisheries, **46**: 489–508. 1931.

thousand bushels to each acre of ground, and that three hundred oysters make up one bushel, we arrive at the conclusion that the oysters of Long Island Sound deposit in their bodies about 7.5 metric tons of pure copper annually.

Space does not permit us to discuss the accumulation and possible rôle of strontium, found in the Radiolaria; barium, which was discovered as crystals of barium sulphate in the protoplasm of *Xenophyophora;* vanadium, discovered in the blood of Ascidians in which it apparently plays a rôle in the respiratory exchange of gases; and other elements (Zn, Mn, K, S, Fe, P, Al, etc.) which are accumulated by various forms.

After the death of the organism the accumulated material is deposited on the bottom and enters into new reactions resulting in the formation of various minerals found in the sedimentary rocks. Here the field of biology ends and we enter into realm of geology and mineralogy. Although the boundary line is indistinct, and the processes of accumulation of elements in living matter and their further rôle in the formation of minerals on the bottom of the sea are but the different phases of one cycle, we shall not trespass in this field, foreign to biologists, but return to the living organisms and consider how their lives may be affected by slight changes in the chemical composition of the sea water. This field of research scarcely has been touched by scientific investigations and our knowledge is therefore very limited. Interesting progress along this line was made, however, by recent work on oysters.

These molluscs inhabit the inshore waters where the environment is subject to periodical changes caused by the tides. Due to the discharge of river waters the salinity of the inshore area fluctuates quite widely. Consequently, the organisms living in this environment must adapt themselves to considerable fluctuations in osmotic pressure and to changes in the chemical composition of the water concurrent with the different stages of tide. It has been found by Prytherch[16] that the copper content of the water in Long Island Sound fluctuates between 0.1 part per million at high water and about 0.5 part per million at low tide. The increase in copper at low tide is due to the discharge of fresh water by the rivers. On the other hand, it has been observed in laboratory experiments that copper salts have a peculiar effect on oyster larvae, inducing their attachment to the substratum and initiating their metamorphosis. Under experimental conditions

[16] Prytherch, H. F. Science, 73: 429–431. 1931.

the full grown larvae responded to copper treatment very readily and with great precision. By employing this method it was possible for the first time to obtain a complete photographic record of their behavior during setting and metamorphosis. That the peculiar effect was due to copper, but not to other elements which are brought in by rivers, was corroborated by numerous experiments with various salts of Fe, Pb, Zn, Mn, St, Ba, Al, Ni, Co, which gave no positive results. The anions are apparently not involved in this reaction because different copper salts (carbonates, sulphates and chlorides) had exactly the same effect.

The results of the laboratory experiments were corroborated by field observation. Prytherch observed the intensity of setting of oyster larvae by counting at brief intervals the number of larvae attached to a plate that had been placed in the bay. The intensity of setting increases with the increase in copper content of the water, the latter reaching its maximum at low tide. The two curves run parallel and are undoubtedly significant. These observations explain the peculiarity in the distribution of the natural oyster beds which occur mainly in the mouths of rivers. Apparently the river water, having a higher copper content, supplies the necessary stimulus that initiates the "setting" reaction of the full grown oyster larvae. The result is that the best setting areas are found on bottoms affected by fresh water. We are, however, ignorant as to the biochemical reaction involved in this phenomenon. It is extremely interesting that the organism reacts in a very distinct manner to slight fluctuations in the content of this metal, ranging only from 0.1 to 0.5 part per million. Greater concentrations of copper ions are distinctly injurious to the larvae causing the disintegration of their tissues and death. We are dealing here with an extremely well adjusted and sensitive mechanism which responds to slight changes in the environment.

The fluctuation in the concentration of other elements due to tidal changes may also have a pronounced effect on the activity of the organism. Hopkins, working in the Gulf of Mexico, has noticed considerable fluctuations in the potassium salts. Also in his work on the chemical sensitivity of the oyster[17] he found that the potassium ion has greater stimulating power in comparison with other metals. It is quite probable that fluctuations in the chemical composition of the environment may have a profound effect on all marine forms, and that they greatly influence their feeding, growth, and propagation.

[17] Hopkins A. E. Journ. Exp. Zool. 61: 13–29. 1932.

Further research along this line, which is now under way, will probably throw more light on the relation between the organism and its environment. It is quite permissible to suppose that eventually the explanation of so-called lunar cycles in the behavior of various marine forms will be found in the periodical chemical changes which occur in the environment and in the organisms themselves.

So far we have been dealing with the inorganic constituents of sea water. But sea water contains also various products of metabolism given off by the organisms. Although they occur only periodically and cannot be regarded as constituents of the sea water, yet some of them play an important rôle in propagation of marine forms by stimulating the shedding of their eggs and sperm. The chemical composition of these substances is wholly unknown but one of their typical characteristics is the specificity of their action. The presence of these specific agents has been demonstrated by the experiments with *Nereis* (Lillie and Just[18]), sea urchins (Fox[19]), and both edible and pearl oysters (Galstoff[20]). The latter experiments have shown that the female oysters discharge a certain substance which has a specific effect on the males of the same species causing an immediate discharge of sperm. The substance is soluble in sea water and withstands boiling for ten minutes. The sperm discharged by the males contains an active principle which initiates in a female a complex reaction consisting of rhythmical contractions of the adductor muscle, contraction of the mantle, and discharge of eggs. The specific agent of sperm suspension is insoluble in sea water and is very unstable, being destroyed by heating for fifteen minutes at 60°C. This active principle of the sperm is effective only under definite thermic conditions. In the *Ostrea virginica*, the reaction occurs only if the temperature of the water is above 20°C. The specificity of the reaction was established by experiments with various molluscs, *Mytilus*, *Mya* and with different species of oysters (*O. cucullata*, *virginica* and *sandwichensis*). In case of *O. virginica* and *O. cucullata*, it has been found by the author that the males can be induced to spawn only by the eggs or egg water of the same species and fail to respond to the addition of foreign eggs.

It is interesting that in spite of this specificity, the reaction can be provoked also by an increase in temperature. The author's latest experiments, carried out in 1931, show that ripe males and females of *O. virginica* can be induced to spawn by taking them from water of 19°C. and keeping them at a temperature above 24.5°C. Below

[18] Lillie, F. R., and Just, E. E. Biol. Bull. **24**: 147–159. 1913.
[19] Fox, M. Proc. Cambr. Phil. Soc. Biol. Sc. **1**: 71–74. 1924.
[20] Galtsoff, P. S. Proc. Nat. Acad. Sc. **16**: 555–559. 1930.

24.5°C. the temperature alone is insufficient to induce spawning of the female, which, however, readily responds to the addition of sperm. From these observations an inference can be made that sperm plays the rôle of a "key" that unlocks a certain mechanism which in turn initiates in the female a chain of reactions and that the same results can be obtained also by a physical factor (increase in temperature). The reaction is, however, highly specific in the sense that under certain temperature conditions (between 20 and 24.5°C.) it appears to be provoked only by the sperm of the same species.

There is no doubt that the sexual reactions just described fall in the category of chemical stimulations, which play an important rôle in the life of marine organisms, especially of the sedentary forms like the oyster which possess no organs of vision, but have a well developed chemical sense, and are able to detect slight concentrations of various substances.

The few examples discussed in the present paper show very clearly that many problems of oceanic biology can be studied from a biochemical point of view. We may look upon an organism in the sea as part of a complex chemical cycle in which a given form is only one of the links in a long chain of cyclic reactions; or we may study it with the purpose of understanding the factors controlling its propagation, development, functioning of its body and peculiarities of its behavior. In all cases we are dealing with biochemical problems which can be attacked by an experimental method. We know that marine forms play a definite rôle in the chemical cycles of various elements occurring in sea water, and that on the other hand they are very delicately adjusted to their particular habitats. It is our hope that an understanding of their work and of the mechanism of their adjustment can be reached through biochemical and physiological studies which open up new fields of research and should lead to the solution of problems which the descriptive methods, so generally used in oceanography, were unable to solve.

ZOOLOGY.—*On a new Cyprinoid from South Dakota.*[1] SAMUEL F. HILDEBRAND, U. S. Bureau of Fisheries. (Communicated by WALDO L. SCHMITT.)

An apparently undescribed species of the genus *Hybognathus* occurs among a lot of cyprinoids submitted for identification by Dr. E. P. Churchill of the University of South Dakota. The writer takes pleas-

[1] Published by permission of the U. S. Commissioner of Fisheries. Received March 29, 1932.

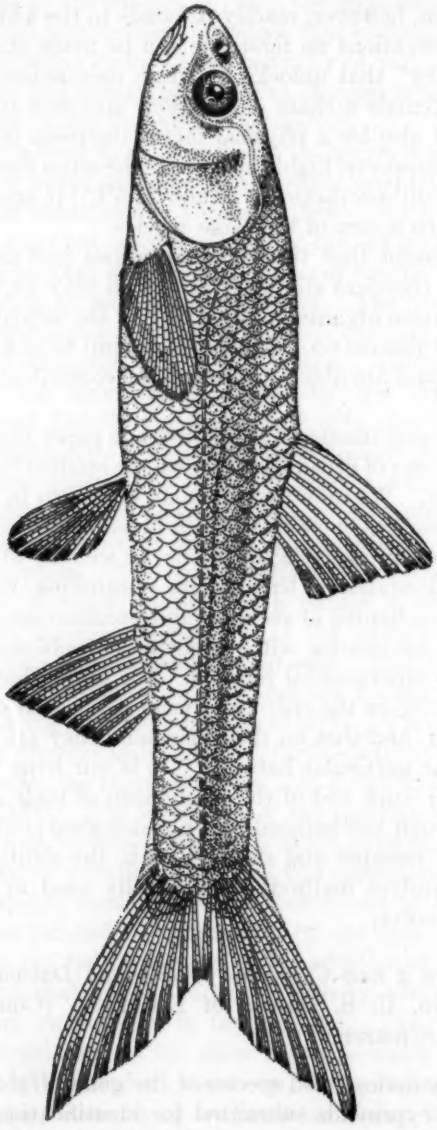


Fig. 1. *Hybognathus churchilli*. Total length, 71 mm. Drawn from the type by Louella E. Cable of the U. S. Bureau of Fisheries.

ure in naming this fish for Doctor Churchill who collected the specimens and who has made an extensive study of the fishes of South Dakota.

Hybognathus churchilli sp. nov.

Type No. 92248 U. S. National Museum; length 71 mm.; Cheyenne River, S. D.

Description of the type.—Body very elongate and slender, not strongly compressed, about three-fourths as broad as deep at origin of dorsal, the greatest depth contained in length to base of caudal 5.2 times; the peduncle compressed, its depth 2.3 in head; head low and rather broad, 4.1 in length of body to base of caudal, its depth at middle of eyes 2.3 in its length to bony margin of opercle; interorbital moderately convex, 3.5 in head; eye small, 5.6 in head; snout moderately conical, projecting about half an eye's diameter beyond the mouth, its length 3.7 in head; mouth slightly oblique, the gape reaching almost opposite posterior nostril; scales small and thin, especially reduced in advance of dorsal, 41 oblique rows running upward and backward between upper anterior angle of gill opening and base of caudal, 6 complete rows between origin of dorsal and lateral line, 4 between origin of anal and lateral line, 20 oblique rows crossing the back in advance of dorsal; dorsal with 8 branched rays the longest rays a little shorter than head, none of them produced, the fin having no high lobe anteriorly, its origin slightly nearer tip of snout than base of caudal; the caudal deeply forked, the lobes pointed and of nearly equal length; anal with 8 branched rays, a little lower than dorsal, its origin below tips of the longest rays of the dorsal when deflexed; ventral fins smaller than the pectorals, inserted slightly behind the vertical from origin of dorsal; pectoral fins failing to reach base of ventrals by a distance equal to length of snout, 1.3 in head.

Color after preservation in formalin slightly brownish above, with dusky punctulations, paler below and without punctulations (the sides no doubt are silvery in life, although this no longer is evident); a dusky vertebral streak in advance of dorsal; a slight indication of a dusky lateral band; the fins unmarked. (Fig. 1.)

Variations.—The variations within the species, as far as shown by 10 paratypes, are not pronounced. The following proportions and counts give the range within the specimens at hand: Head 3.9 to 4.25; depth 4.9 to 5.6 in standard length; eye 5.0 to 5.75; snout 3.1 to 4.0; interorbital 2.7 to 3.5; depth of head at middle of eye 2.0 to 2.4; caudal peduncle 2.2 to 2.7 in head. D. 8; A. 7 or 8; scales 18 to 21 before dorsal, sometimes crowded, irregular and difficult to enumerate, 40 to 44 in lateral series, 6 complete rows above the lateral line and 4 below it, counted respectively at origin of dorsal and of anal. Pharyngeal teeth in 3 specimens examined 0,4–4,0, compressed and slightly hooked at tips. Peritoneum jet black; intestine long and coiled. Origin of dorsal usually equidistant from tip of snout and base of caudal, occasionally slightly nearer the snout; the anterior rays of the dorsal sometimes somewhat produced, seldom sufficiently to make the fin falcate; ventral fins inserted under or slightly behind vertical from origin of dorsal.

Relationship.—The present species apparently is more slender than others

of the genus, and the scales are small, being especially reduced in advance of dorsal. Comparing the present species with *H. nuchalis*, the other common local species, it is evident that the body is more slender (the range in depth in 7 specimens of *nuchalis* being 4.36 to 4.9); the eye is smaller, a difference which is most evident when specimens of the same size are compared, for example, in 3 specimens of *churchilli* all about 80 mm. long the eye is contained in the head respectively 5.5, 5.5 and 5.28 times, whereas in *nuchalis* in 3 specimens of about the same length the eye is contained in the head respectively 4.4, 3.85 and 4.3 times. The scales, especially in advance of the dorsal are larger, the range in 7 specimens of *nuchalis* being 14 to 15 in advance of dorsal, 35 to 38 in a lateral series, and 5 above the lateral line and 4 below it, counted respectively at the origin of the dorsal and origin of anal. The snout projects a little more strongly beyond the mouth in *churchilli* and the anterior rays of the dorsal are rather shorter, not forming a definite lobe.

The specimens of the present species were compared with 7 type specimens of *H. argyritis*, recorded from the upper Missouri basin, and originally described from the Milk River. The present species differs from that species also in the more slender body and smaller scales. In *argyritis* the snout projects beyond the mouth even more strongly than in *H. churchilli*.

Specimens of *Hybognathus churchilli* studied.—a. Seven specimens (including the type), ranging in length from 62 to 105 mm., from the Cheyenne River, near the mouth of Cherry Creek, taken July 15, 1928. b. Three specimens, ranging in length from 63 to 65 mm., from the White River near the town of White River, taken June 18, 1928. c. One specimen, 78 mm. long, from Bad River near Midland, taken July 16, 1928. The specimens were all collected by Dr. E. P. Churchill, who informs the writer that the Cheyenne and White Rivers are shallow, swift alkaline streams with little vegetation, whereas the Bad River is not alkaline, is sluggish and supports considerable vegetation. *Hybognathus nuchalis* also was taken in these rivers.